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Sunil J. Kulkarni
PhD student, Sant Gadgebaba Amravati University, Amravati, Maharashtra, India

Jayant P. Kaware
Sant Gadgebaba Amravati University, Amravati, Maharashtra, India

Correspondence:
Sunil J. Kulkarni
pHD student, Sant Gadgebaba Amravati University, Amravati, Maharashtra, India

Desorption studies for low cost adsorbents

Sunil J. Kulkarni, Jayant P. Kaware

Abstract
Adsorption for wastewater treatment has been extensively studied and practiced method. It can selectively used for removal of certain pollutant by selection of suitable adsorbent. The used adsorption has to be discarded after it becomes exhausted. Commercial adsorbents can be regenerated and reused. The disposal of adsorbent is again solid treatment and disposal problem. The maximum regeneration and reuse is advised in order to make the operation environmental friendly. The current investigations aim at exploring the possibility and effectiveness of low cost adsorbent regeneration. The results indicate that the phenol desorption up to 40.7 and 30.9 for GNSA and RHA respectively and cadmium desorption up to 25.1 and 26.03 is possible for GNSA and RHA adsorbents respectively. The results indicates that there is need to study desorption of cadmium and phenol and explore more economical and effective option for adsorbent regeneration.

Keywords: adsorbent, adsorbate, percentage desorption, reuse, recovery

Introduction
Adsorption is one of the major unit operation used for removal of various pollutants from wastewater. It offers flexibility in terms of selection of contacting devices and adsorbent material depending on the time, space and funds available for treatment of the wastewater. Low cost adsorbents prepared from rice husk, coconut shell, tamarind bean shells, fly ash, leaf litters, cashew nut shells, tea waste has been used effectively [1,2,3,4]. Many of adsorbents are found effective in removal of organic matter, phenol and heavy metals [5, 6, 7]. In our earlier research, investigation was carried out for removal of phenol and cadmium by using adsorbents prepared from rice husk and ground nut shells [8, 9, 10, 11]. The results obtained were encouraging. One of the major aspect that is not given due importance in the related research is reuse of adsorbent and desorption of adsorbate [12, 13, 14]. In order to make the adsorption more economical and viable alternative, it is important to minimize the requirement of adsorbent [15]. In the present investigation an attempt is done to study the desorption of these two pollutants from adsorbent in batch mode.

Literature Review
Various investigators have carried out research on phenol desorption. Bhatia *et al.* studied effect of various parameters like agitation speed, temperature and phenol concentration on desorption in aqueous phase [16]. According to them external mass transfer resistance can be avoided by proper choice of agitation speed. Also they observed that rate of desorption increased with an increase in temperature. Vasu used water, dilute acetic acid and dilute HCl as eluent. He achieved phenol desorption of 70 percent [17]. Investigations on sorption and desorption kinetics of chlorophenols in hexadecyltrimethyl ammonium-montmorillonites was carried out by Kim *et al.* They found that 71% of 2-Chlorophenol (ChP), 34% of 2, 4-Di ChP, and 17% of 2,4,5-Ttri ChP was desorbed within 30 minutes [18]. Haydar *et al.* carried out adsorption desorption studies for olive stone activated carbon [19]. Moreno-Castilla *et al.* studied thermal desorption process for phenol, m-aminophenol, p-cresol and p-nitrophenol [20]. They investigated thermal desorption process for phenol, m-aminophenol, p-cresol and p-nitrophenol. They observed that during thermal regeneration, 6 percent of phenol was desorbed at 300-425 ^{o}C. Research on desorption of heavy metal desorption from adsorbent was carried out by various investigators. Hsien and Liu performed single stage and multiple stage experiments using porous chitosan beads [21]. They added 0.1 N HNO_3 solution to the vessel to load the bulk solution for the H^+ ions. They observed that cadmium concentration increased sharply during the first 12 hours of desorption. In their investigation, Ugwekar and Lakhawat

used peanut hull for preparation of adsorbent [22]. Adsorption and desorption experiments for heavy metal removal by using marine algae were carried out by Carsky and Mbhele [23]. The column service time decreased from 25 hrs in the first cycle to 10 hrs for the last cycle. According to studies carried out by Maleki, the desorption of cadmium by batch process was 8% usind distilled water [24]. In the present investigation desorption studies are carried out to desorb phenol and cadmium from adsorbents prepared from rice husk and groundnut shells. First adsorption was carried out in batch mode at optimum conditions of pH, initial concentration, adsorbent dose and contact time. Then desorption studies were carried out.

Methodology

Rice husk adsorbent was prepared and activated by thermal and chemical methods. First batch adsorption experiments were carried out at optimum operating parameters. For phenol removal by rice husk adsorbent, the contact time, pH and adsorbent dose was 100 minutes 5 and 2.5 grams respectively for 100 ml of effluent. For phenol removal by groundnut shell adsorbent, the optimum values for contact time, adsorbent dose, pH taken as 120 minutes, 3 grams per 100 ml, 6 as obtained in earlier experiments [8, 10]. Similarly for cadmium removal initial concentration, pH and adsorbent dose were 50 mg/l, 5 and 2.5 grams for groundnut shell activated carbon. Contact time was 90 minutes [9]. For rice husk carbon these values were 60 mg/l, 5.5, and 2.5 grams per 100 ml. Optimum contact time was 40 minutes. After carrying out adsorption experiment, the used adsorbent was sundried. Then it was taken in 250 ml conical flasks and 100 ml of solvent was added to it. The flask was agitated and the samples were withdrawn after every 30 minutes for analysis.

Results and Discussion

Phenol desorption

As shown in figure 1, the maximum desorption was 40.7 percent for dil. HCl followed by dil. sulphuric acid for GNSA. By using distilled water 20.9 percent desorption was obtained. The time taken for desorption was 330,360, 390 minutes. After this, no further desorption was observed. This indicates that considerable part of phenol adsorbed was due irreversible sorption. Chemisorption has significant effect on phenol removal.

As shown in fig.2, for rice husk adsorbent, dil. sulphuric acid was found to be best solvent for phenol desorption with 30.9 percent desorption in 410 minutes. By using dil. HCl and distilled water 20.7 and 18.2 percent desorption was possible. In similar experiments with commercial activated carbon Vasu (2007) [17] obtained 25.49 percent desorption by distilled water and 70 percent for dil. HCl. Bada (2007) [25] obtained 17.9 percent desorption by using distilled water for fly ash adsorbent.

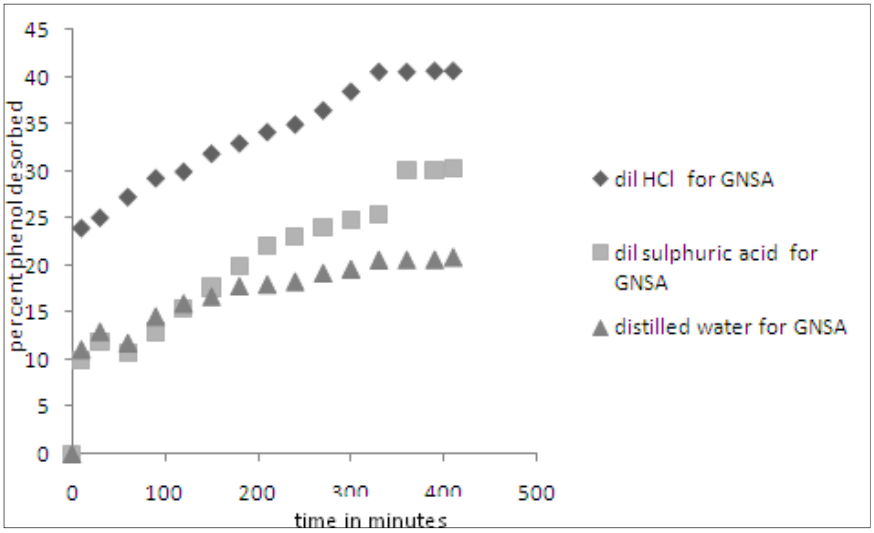

Fig 1: Desorption of phenol for GNSA adsorbent

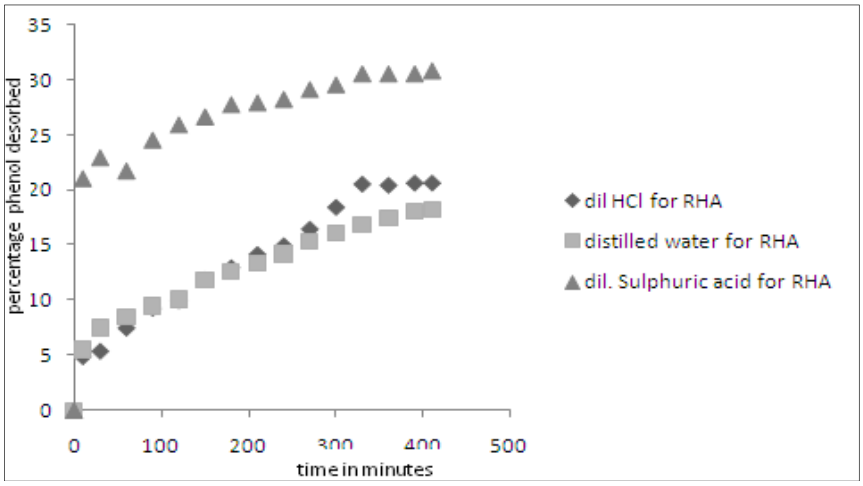

Fig 2: Desorption of Phenol for RHA Adsorbent

Cadmium desorption

Cadmium desorption was carried out with 100 ml of solvent and 60 mg/l initial concentration. Three solvents were used namely dil. HCL, distilled water and dil. sulfuric acid. As shown in fig 3, the percentage desorption obtained by these three solvents was 24.6, 12.7 and 25.1 respectively for GNSA. Kadirvelu and Namasivayam (2003) [26] obtained the maximum percentage recovery of Cd(II) was 100% with 0.075 M HCl solution From Hazel Nut Shell adsorbent, Jamali obtained 12 percent desorption by using distilled water (Jamali, 2009) [27]. Investigations carried out by El-Said (2012) [28], Mishra (2014) [29] have yielded similar results. The percentage desorption by using dil. acids is reported in different research articles ranges from 20 percent to 100 percent. For RHA maximum desorption 26.1 percent was obtained by using dil. sulphuric acid.

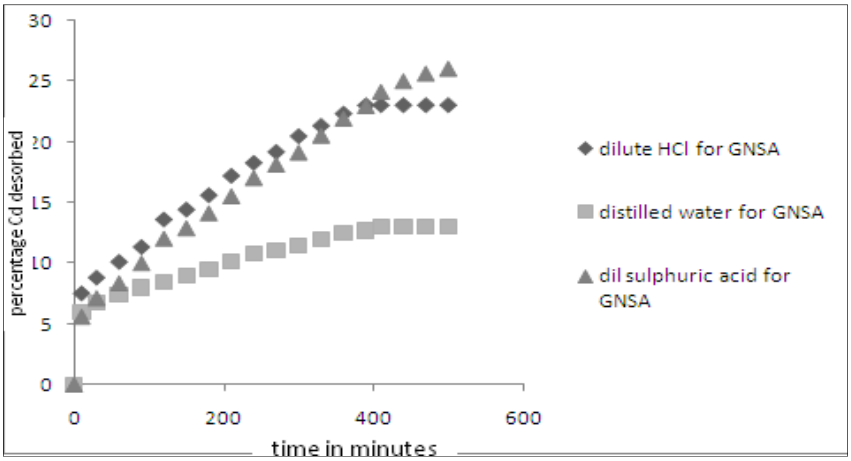

Fig 3: Desorption of Cadmium for GNSA Adsorbent

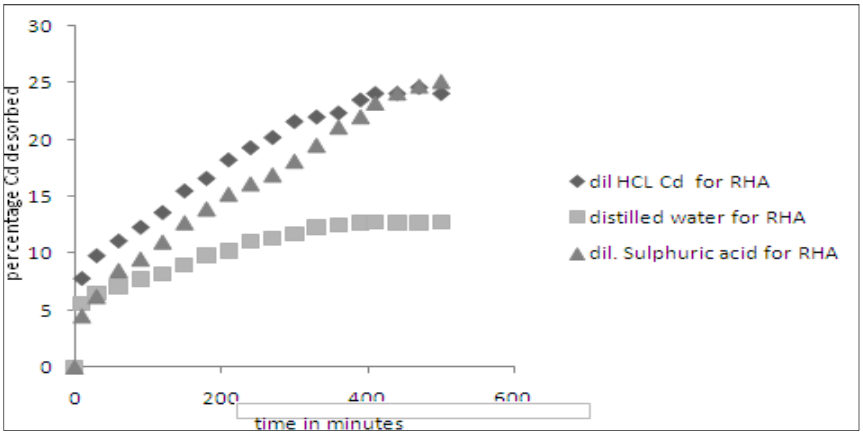

Fig 4: Desorption of Cadmium for RHA Adsorbent

Conclusion

The results for desorption experiments were though not excellent but encouraging. Results indicate that the phenol desorption up to 40.7 and 30.9 for GNSA and RHA respectively and cadmium desorption up to 25.1 and 26.03 is possible for GNSA and RHA adsorbents respectively. It can be concluded that there is need to study desorption of cadmium and phenol and explore more economical and effective option for adsorbent regeneration.

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